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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

A Silencer for Jet Systems

We, SOCIETE NATIONALE D'ETUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION, a French Body Corporate, of 150, Boulevard Haussmann, Paris 75, France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a silencer for a jet system of the kind in which there are distributed, around the jet which is to be silenced, a series of controllable elements which can be adjustably moved between an operative position in which they project into the said jet in order to create, by a constrictive effect at the periphery of said jet, a series of disturbances or corrugations equal to the number of such elements, and an inoperative position in which the said elements are retracted away from the jet.

As those skilled in the art will be aware, the presence of corrugations in the periphery of a jet has the effect of increasing the surface area of the jet which is in contact with the surrounding atmosphere and of thus promoting mixing between the gas of the jet and the surrounding air, something which, as also is well known, is an important factor in achieving attenuation of the noise produced by the jet.

Thus, in connection with the specification of French Patent of Addition No. 86258, which is concerned in particular with a jet propulsion nozzle comprising a primary duct through which in operation there flows the jet which is to undergo noise suppression, said primary duct opening into a secondary duct bounded by a fairing of larger cross-section than the primary duct and extending downstream to a point beyond the exit from said primary duct, which secondary duct is adapted

in operation to pass a secondary gas flow, we have proposed a silencer comprising hollow controllable elements articulated to the fairing to swing about axes substantially parallel to the nozzle axis, said hollow elements being designed to swing between an inoperative position in which they are retracted into the structure of the fairing, and an operative position in which they open transversely into the jet whose noise is to be suppressed, then discharging through their downstream extremities secondary air, which has been induced through their upstream ends, into the jet.

In the silencing position, the combined mechanical and aerodynamic action of the controllable elements has the effect of producing at the periphery of the primary jet, corrugations or disturbances which bring about attenuation of the noise. The number of controllable elements which can be used is, however, limited by the length or depth of the elements, which must be sufficient to enable them to penetrate into the primary jet in a position effective for silencing, and by the peripheral length of the fairing into which they are required to retract in the condition of cruising flight. The result is that in the gap between two consecutive controllable elements, there is a certain peripheral extent of the jet which contains no corrugation and is therefore not subjected to the noise attenuating effect.

The invention is intended to overcome the drawbacks arising out of the use of too limited a number of controllable elements, whatever may be the reason for this limitation, by providing means which can act on the whole of the periphery of the primary jet and thus achieve maximum noise suppression.

In accordance with the invention, in a silencer of the kind specified, at least some of the controllable elements each carry at

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least one constricting device which, in the operative position of the element carrying said device, is adapted, to produce in the peripheral portion of the jet located between two disturbances of corrugations created by consecutive controllable elements, one or more supplementary disturbances or corrugations.

In accordance with one embodiment, the auxiliary constrictive device may comprise a mechanical obstacle which, in the operative position, projects into the jet whose noise is to be suppressed.

In one advantageous embodiment, the mechanical obstacle may comprise a thin strip or plate, for example in accordance with the lamina-like flaps described in our Specification No. (concurrent Application No. 2638/68) (Serial No. 1141784).

In this context, it has been shown that the strip should preferentially operate on the jet in a zone at which it has already expanded, and that its effective part is that which, in the silencing position, is in the neighbourhood of the boundary of the primary jet. In accordance with the present invention, the strips or plates are carried by the controllable elements; each strip or plate, thus made rigid with one of the controllable elements, can then be retracted along with said element into the interior of the fairing.

In accordance with another embodiment, the auxiliary constrictive device may comprise a fluid obstacle in the form of at least one jet of pressurised fluid issuing from an injector directed transversely to the jet the noise of which is to be suppressed. The action of auxiliary jets of this kind has been explained in our Specification No. (concurrent Application No. 2639/68) (Serial No. 1183893).

It has been shown, in particular, that injection of such auxiliary jets should be effected in a zone in which the jet whose noise is to be suppressed has expanded to a sufficient extent for the disturbance caused by the action of the auxiliary jets to be pronounced and not liable to die away due to reforming of the jet to be suppressed.

In accordance with a feature of the invention, the injectors for introducing the pressurised fluid auxiliary jets are integral with the controllable elements and are retracted into the fairing along with them. In accordance with one relevant embodiment of said feature, a jet injector associated with a controllable element is connected to at least one fixed main through the medium of a system of flexible hoses or adjustable pipes with swivel joints. In the event that the jet system is constituted by the propulsion nozzle of a jet propulsion engine, the main referred to hereinbefore may advantageously be connected to the delivery side of a compressor in the engine.

The following description relating to the accompanying drawings indicates, by way of

a non-limitative example, how the invention may be put into effect.

In the drawings:—

Figure 1 is a schematic transverse half-section through a propulsion nozzle incorporating a silencer of known type;

Figure 2 is a schematic transverse half-section through a propulsion nozzle incorporating a silencer in accordance with the invention;

Figure 3 is an enlarged transverse section of part of a propulsion nozzle slightly modified with respect to that shown in Figure 2;

Figure 4 is a top longitudinal half-section of the nozzle shown in Figure 3, viewed in the direction of the arrow A;

Figure 5 is a partial transverse section of a propulsion nozzle containing a silencer in accordance with another embodiment of the invention; and

Figure 6 is a top longitudinal half-section of the nozzle shown in Figure 5, viewed in the direction of the arrow A.

In these drawings, there is shown by way of example a propulsion nozzle of the kind which comprises a primary duct opening into a secondary duct, the latter bounded by a fairing 4 which extends downstream beyond the exit 2 of the primary duct. This fairing 4, the transverse cross-sectional area of which is larger than that of the primary duct, comprises an external wall 5 and an internal wall which successively creates a convergent zone 6, a throat 7 and a divergent zone 8, and terminates in an arrangement of control flaps 9.

In operation, there passes through the primary duct, in the direction of the arrow f, a primary jet the external boundary of which has been designated by the reference 3, whilst the annular space 10 formed between the internal wall of the fairing 4 and the external wall of the nozzle 1 followed by the boundary 3 of the primary jet, is the location of a secondary air flow of relatively low energy, indicated by the arrow F.

A short distance downstream of the throat 7 in the fairing, there are peripherally distributed a selected number of controllable elements 11 of the kind proposed in our above-mentioned French Patent of Addition.

These elements may each be given the form of a hollow triangular prism recessed at 11a and open at the base 11b. A linkage schematically indicated at 11d enables each of the elements to pivot on hinges 14 about substantially longitudinal axes 11c. These elements can thus be moved from an operative or swung-in position, indicated in full-line in Figures 1 and 2, and in broken-line in the other Figures, to an inoperative or retracted position, indicated in broken-line in Figure 2 and in full-line in the other Figures.

In the inoperative position, generally speaking the flight cruising condition, each of the

elements is retracted into the divergent portion of the fairing, so that it produces no loss of thrust.

In the operative position, that is to say in the take-off or other condition in which silencing is required, each element will be swung near-radially towards the primary jet, so that it extends into said jet to a small extent. Secondary air is induced through the recess 11a into the hollow element 11, flowing through it in the direction of the arrow 12 before exiting through the base 11b thereof.

The combined mechanical and aerodynamic action of the element 11 and of the air flow 12, both of which penetrate into the primary jet flow, produces in said primary flow a local disturbance similar to a constriction, the effect of which is the more marked and "permanent" the more this constriction is moved into a zone of the primary jet in which the jet has already undergone substantial expansion, that is to say into a zone located at a relatively distant point downstream from the exit 2 of the primary duct.

Figure 1 indicates in a schematic manner, the effect which is consequently produced upon the boundary 3 of the primary jet flow. In the silencing condition, this boundary has a generally corrugated form, shown at 13, with as many zones 13a of local constriction as there are controllable elements 11. Due to the fact that the total cross-sectional area of the jet, in the disturbed condition, is substantially equal to that of the jet in the undisturbed condition, it will be observed that there are formed, in the intervals between two consecutive elements 11, very slight corrugations 13b in the other direction.

Obviously, it would be desirable to increase as far as possible the number of the corrugations and, accordingly, the number of controllable elements; however this number is subject to a top limit, for reasons which have been explained hereinbefore, which is very rapidly reached. This limitation means that the boundary 13, as Figure 1 indicates, exhibits between the consecutive controllable elements zones in which there is no substantial degree of corrugation at all.

Figures 2 to 6 illustrate different means of creating, between consecutive controllable elements, supplementary local constrictions in the jet upon which noise suppression is being carried out.

In accordance with Figures 2 to 4, strips or plates 15 are fixed to the controllable elements 11 through the medium of flat bars 16, 17, riveted or welded to the said strips or plates and to the elements 11. Since the strips or plates 15 are firmly fixed to the elements 11, they retract with the elements 11 into the fairing in the cruising condition. In the silencing condition, these strips or plates penetrate into the jet and produce dis-

turbances in its boundary by creating supplementary corrugations 18a in the disturbance contour 18, as shown in Figure 2.

The noise produced by the jet, when it has a disturbance contour such as that referenced 18, is substantially less marked than that which it produces when the contour is like that referenced 13, due to the creation of twice the number of corrugations.

Figures 5 and 6 illustrate a variant embodiment of the invention in accordance with which the intermediate constriction of the primary jet is effected using fluid injectors 23 rigid with the elements 11. These injectors are supplied with compressed fluid, such as high-pressure air, taken from a compressor which forms, for example, part of the jet propulsion engine.

Each injector may be surrounded by a collar 24 rigidly connected with a controllable element 11 through the medium of flat bars 25 riveted or welded to said element.

The supply of compressed fluid is effected from a main 21 to which there are welded connectors 26 linked with the injectors through hoses 27 or through a system of rigid pipes with swivel joints.

In the silencing condition, the elements 11 act in co-operation with the injectors 23, after the opening of a valve (not shown) which controls the supply of compressed fluid to the main 21. High-pressure jets 22 then penetrate transversely into the primary jet whose noise is to be suppressed; at the same time secondary air is induced into said primary jet through the element 11.

In cruising condition, the elements 11 and the injectors carried thereby are retracted into the divergent portion of the fairing.

It will be appreciated that the embodiments described above are simply examples and that various modifications thereof are possible within the scope of the present invention, as defined by the appended claims. Thus, in particular, it would be possible to employ controllable elements 11 of a different kind (for example solid elements), and to employ auxiliary constrictive devices of different design. It would also be possible to adapt the elements 11 to carry auxiliary constrictive devices of type varying from one element to the next, or again to make certain elements carry more than one auxiliary constrictive device, of the same or of different kind leaving others free.

WHAT WE CLAIM IS:—

1. A silencer for a jet system, of the kind in which there are distributed, around the jet which is to be silenced, a series of controllable elements which can be adjustably moved between an operative position in which they project into said jet in order to create, by a constrictive effect at the periphery of said jet, a series of disturbances or corrugations

equal in number to the number of said elements, and an inoperative position in which they are retracted away from the jet, in which silencer at least some of the controllable elements each carry at least one auxiliary constrictive device which, in the operative position of the element carrying said device, is adapted to produce in the peripheral portion of the jet located between two disturbances or corrugations created by consecutive controllable elements one or more supplementary disturbances or corrugations.

2. A silencer as claimed in claim 1, in which the auxiliary constrictive device is constituted, at least in part, by a mechanical obstacle which, in the operative position, projects into the jet whose noise is to be suppressed.

3. A silencer as claimed in claim 2, in which the mechanical obstacle is constituted by a thin strip or plate.

4. A silencer as claimed in any one of the claims 1 to 3, in which the auxiliary constrictive device comprises a fluid obstacle.

5. A silencer as claimed in claim 4, in which the fluid obstacle comprises at least one jet of pressurised fluid issuing from an injector directed transversely to the jet whose noise is to be suppressed.

6. A silencer as claimed in claim 5, in which the injector is connected to at least one fixed main through the medium of a system of hoses or adjustable tubes associated with swivel joints.

7. A silencer as claimed in claim 6, applied to a jet propulsion engine nozzle, in which the main is connected to the delivery side of a compressor in the said engine.

8. A silencer as claimed in any one of the claims 1 to 7, applied to a jet propulsion nozzle of the kind which has a primary duct through which in operation there flows the jet which is to undergo noise suppression, said primary duct opening into a secondary duct bounded by a fairing whose cross-section is larger than that of the primary duct and extends downstream of the exit from the said primary duct, which secondary duct is adapted in operation to pass a secondary gas flow, in which silencer the controllable elements carrying their associated respective auxiliary constrictive devices, can be retracted in the inoperative position into the structure of the fairing.

9. A silencer as claimed in any one of the claims 1 to 8, in which at least some of the controllable elements comprise tubular elements open at both ends and discharging through their downstream ends, into the jet whose noise is to be suppressed, secondary air which has been entrained through their upstream ends.

10. A silencer for a jet system substantially as hereinbefore described with reference to Figure 2 or Figures 3 and 4 or Figures 5 and 6 of the accompanying drawings.

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Fig: 1

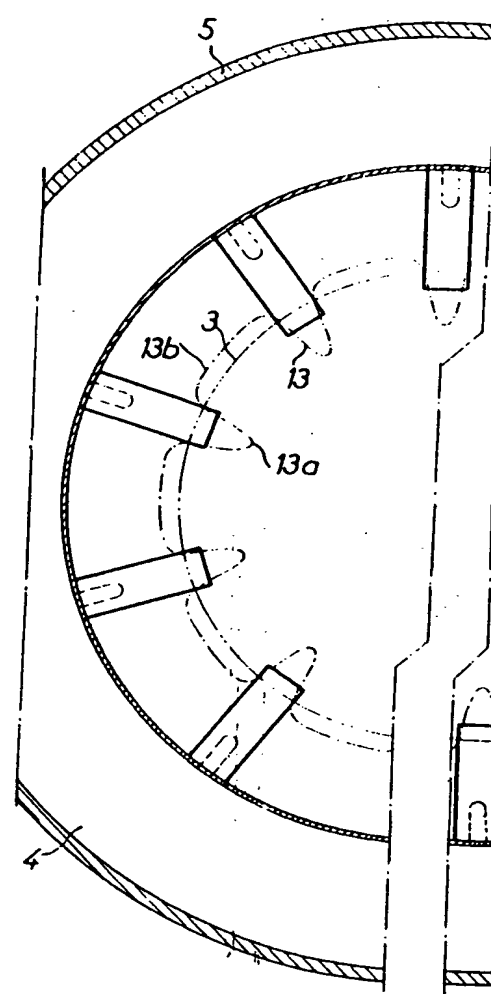


Fig: 2

